

# Characteristics of COVID-19 infection clusters occurring among workers in several Asia-Pacific countries

Mila TEJAMAYA<sup>1#</sup>, Wantanee PHANPRSIT<sup>2#</sup>, Jiwon KIM<sup>3#</sup>, Feng-Jen TSAI<sup>4#</sup>, Go MUTO<sup>5#</sup>, Derek MILLER<sup>6</sup>, Alex REGINALD<sup>7</sup>, Nelia GRANADILLOS<sup>8</sup>, Carmela CAPULE<sup>9</sup>, Marina Bt ZAINAL FARID<sup>10</sup>, Yu-wen LIN<sup>11</sup>, Jihoon PARK<sup>12</sup>, Ruey-Yu CHEN<sup>13</sup>, Kyong Hui LEE<sup>14</sup>, Jeongim PARK<sup>15</sup>, Haruo HASHIMOTO<sup>16</sup>, Haesong KWON<sup>17</sup>, Chungsik YOON<sup>18</sup>, Chantana PADUNGTOD<sup>19</sup>, Elsy As SAFIRA<sup>20</sup> and Dong-Uk PARK<sup>3\*</sup>

<sup>1</sup>Faculty of Public Health, University of Indonesia, Indonesia

<sup>2</sup>Department of Occupational Health and Safety, Faculty of Public Health, Mahidol University, Thailand

<sup>3</sup>Department of Environmental Health, Korea National Open University, Republic of Korea

<sup>4</sup>Ph.D. program in Global Health and Health Security, Taipei Medical University, Taiwan

<sup>5</sup>Department of Hygiene, Kitasato University School of Medicine, Japan

<sup>6</sup>D Miller Consultancy, New Zealand

<sup>7</sup>Christian Medical College, Vellore, India

<sup>8</sup>Occupational Safety and Health Center, Republic of the Philippines

<sup>9</sup>Industrial Hygienists Association of the Philippines, Republic of the Philippines

<sup>10</sup>Malaysian Industrial Hygiene Association, Malaysia

<sup>11</sup>Department of Public Health, Fu-Jen Catholic University, Taiwan

<sup>12</sup>National Institute of Chemical Safety, Ministry of Environment, Republic of Korea

<sup>13</sup>School of Public Health, Taipei Medical University, Taiwan

<sup>14</sup>The 65th Medical Brigade, U.S. Army, United States

<sup>15</sup>Department of Environmental Health Sciences, Soonchunhyang University, Republic of Korea

<sup>16</sup>Hashimoto Occupational Safety and Hygiene Consulting, Japan

<sup>17</sup>Changjo Industrial Safety and Health, Republic of Korea

<sup>18</sup>Department of Environmental Health Sciences, Institute of Health and Environment, Graduate School of Public Health, Seoul National University, Republic of Korea

<sup>19</sup>Division of Vector-borne Diseases, Department of Disease Control, Ministry of Public Health, Thailand

<sup>20</sup>Indonesian Industrial Hygiene Association, Indonesia

*Received October 7, 2021 and accepted January 4, 2022*

*Published online in J-STAGE January 12, 2022*

*DOI <https://doi.org/10.2486/indhealth.2021-0227>*

**Abstract: The types of workplaces and occupations with coronavirus 2019 (COVID-19) clusters vary between countries and periods. We aimed to characterize major occupational groups with mass outbreaks of COVID-19 infections in several Asia-Pacific countries. Data on the major**

#The authors contributed equally to this work as the first author.

\*To whom correspondence should be addressed.

E-mail address: pdw545@gmail.com

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occupations or workplaces reporting COVID-19 cases in workplaces from January 2020 to July 2021 was collected from industrial hygiene professionals in nine countries. The proportion of workers accounted for 39.1 to 56.6% of the population in each country. The number of workers covered in the national statistics varies among nations based on their definition of a worker. None of the countries examined here have systematically collected occupational data on COVID-19 illnesses and deaths classified by type of industry, occupation, or job. Most countries experienced COVID-19 clusters among health and social care workers (HSCW) in hospitals or long-term care facilities. The types of occupations or workplaces with virus clusters in some participating countries included prisons, call centers, workplaces employing immigrants, garment facilities, grocery stores, and the military, which differed among countries, except for a few common occupations such as HSCW and those populated by immigrants. Further study is necessary in order to seek ways to control infection risks, including revisions to industrial-health-related laws.

**Key words:** COVID-19, Infection, Asian Network of Occupational Hygiene (ANOH), Occupation virus cluster, Workplace

## Introduction

Since the coronavirus 2019 (COVID-19) pandemic emerged in China in December 2019, the number of infection cases has significantly varied among countries and over time. Most countries have experienced waves of mass COVID-19 infections based on their geographical location, differences in weather conditions and local environments, and public health policy.

Globally, specific workplaces have become centers of COVID-19 outbreaks: call centers in the Philippines; meat processing plants in the U.S., Germany, Ireland, and Canada; and nursing homes in all countries<sup>1-4</sup>. Even when the risk of infectious disease, including COVID-19, does not originate in the workplace, workers infected outside the workplace can transmit a virus to co-workers. Individual workers and workplaces with environments vulnerable to viral infection can be a source of potential mass transmission. Workplaces can play an essential role in spreading a disease<sup>5</sup>. Understanding the wide range of occupations that could be exposed to infection or disease due to the work activities involved is vital for planning risk management and worker communication. Nevertheless no country has systematically collected occupational data on COVID-19-induced illnesses and deaths classified by type of industry or occupation, even though daily statistics on the incidence and death rate of COVID-19 cases have been officially reported<sup>6</sup>. COVID-19 statistics usually show the number of confirmed cases classified by region, sex, and age—but the

occupational factors associated with COVID-19 risk remain elusive. With the ongoing COVID-19 epidemic, there is a pressing need to characterize the role of the workplace in disease transmission, especially regarding the variety of work tasks that could promote the spread of infectious disease<sup>7, 8</sup>. Given that a resurgence can occur at any time, information about the mass outbreaks of COVID-19 that have been experienced in respective countries needs to be shared and discussed in order to ensure that such outbursts are not repeated.

Occupational health (OH) professionals have intimate experience of the impact of work on the health of workers, in circumstances such as this COVID-19 pandemic. The primary aim of OH is to protect workers' health from hazardous agents generated in workplaces. The Asian Network for Occupational Hygiene (ANOH) is the scientific association among OHs from 17 Asia-Pacific countries. A total of 22 board members along with the president generally decide on key efforts including education, conferences, and academic activities, etc. We believe that the views of ANOH board members would, hence, be particularly appropriate for evaluating the effects of this pandemic on workers in the context of health and work.

This study aims to compare major occupational groups with COVID-19 mass outbreaks and to share information useful for infection control by summarizing and providing an overview of COVID-19 clusters in workplaces in different countries. Our results can be used to help devise countermeasures against COVID-19 infection risk and protect workers from infection risk in workplaces.

**Table 1. Incidence of and death rate for COVID-19 infections as of July 31, 2021**

Country	Cumulative incidence rate (/100,000 populations)	Cumulative fatality (/100,000 populations)
Australia	132.0	3.6
China <sup>a</sup>	8.2	0.4
Hong Kong	159.9	2.8
India <sup>b</sup>	2,290.9	30.7
Indonesia <sup>b</sup>	1,246.6	34.4
Japan <sup>b</sup>	722.5	12.0
Malaysia <sup>b</sup>	3,384.7	27.4
Mongolia	5,037.6	24.9
New Zealand <sup>b</sup>	52.1	0.5
Republic of Korea <sup>b</sup>	386.9	4.1
Republic of the Philippines <sup>b</sup>	1,442.6	25.3
Singapore	1,108.7	0.6
Sri Lanka	1,442.2	20.5
Taiwan <sup>b</sup>	65.7	3.3
Thailand <sup>b</sup>	855.7	7.0
Vietnam	145.0	1.2

Note: The data on infected patients in China includes those in Hong Kong and Taiwan in the WHO counting system.

<sup>a</sup>The data for Hong Kong and Taiwan was obtained from Worldometer website (<https://www.worldometers.info/coronavirus/>).

<sup>b</sup>Participating countries in this study.

## Subjects and Methods

### *Participating countries and COVID-19 data collection*

International professional bodies within the Asian Network of Occupational Hygiene (ANOH) were accessed to collect information about COVID-19 mass outbreaks among workers<sup>6</sup>. The patterns and scales of COVID-19 infections as of July 31, 2021 differ among the 16 ANOH member countries (Table 1). OHs, including ANOH board members in nine of these countries, voluntarily participated in this study to characterize COVID-19 infection clusters occurring in workplaces. Those who joined as authors have great industrial hygiene experience at academic institutions or in the governmental and industry sector.

The incidence of and death rates due to COVID-19 infection among ANOH member countries, including the countries participating in this study, were cited from the WHO website as of July 31, 2021 (<https://covid19.who.int/>). We examined national COVID-19 statistics from each country to determine whether they were classified by occupational characteristics such as standardized industry classification (SIC) and occupational classification (SOC), as is done with the classification of industrial accidents.

### *Collection of the major occupational groups with COVID-19 outbreaks*

This study was undertaken using research-designed standardized forms to collect major occupational groups or workplaces with COVID-19 clusters. These standardized means for collecting the information or data from participating countries have been detailed elsewhere<sup>6</sup>. The standardized tables used in this study were open-ended and shared and updated via email or other forms of telecommunication among the authors. The information contained in these tables was provided, reviewed, and discussed by the authors for ensuring the accuracy of the information. The critical information gathered and discussed is as follows;

- The proportion of workers within the population based on the definition of an employee in each country
- The five most frequently-reported occupations or jobs or workplaces with a mass outbreak of COVID-19 in each country. First, we collected the numbers of occupational clusters if there is nation-level statistics classified by occupational factors. If there were no such nation-level statistics, authors representing in each country were asked to subjectively evaluate relative ranking of occupations, jobs and workplaces with the clusters within country. This

**Table 2. General statistics for workforces based on the definition of employees each country**

Country (year cited)	Population	Number of employees (Proportion, %)	Inclusion of the self-employed	Inclusion of platform business workers <sup>a</sup>
India (2020)	1,028,610,000	402,235,000 (39.1)	No	No
Indonesia (2020)	275,825,067	128,454,184 (46.6)	No	No
Japan (2020)	125,620,000	66,460,000 (52.9)	Yes	Yes
Malaysia (end of 2019)	32,730,000	15,073,400 (46.1)	Yes	No
New Zealand (2020)	5,112,300	2,734,000 (53.4)	No	No
Republic of Korea (2019)	51,779,000	27,088,000 (52.3)	No	No
Republic of the Philippines (2020)	109,480,590	45,332,000 (41.4)	Yes	Yes
Taiwan (2020)	23,570,000	11,520,000 (48.9)	Yes	Yes
Thailand (2019)	66,558,935	37,702,701 (56.6)	No	No

<sup>a</sup>Connecting consumers with contractors (or workers) through online platform businesses to perform tasks, also known as the gig economy.

qualitative ranking of clusters was made specifically by authors' subjective evaluation of clusters occurring workplaces based on the information reported by either media or health authority etc. COVID-19 clusters in the workplace were compared and summarized as of July 31, 2021. Major risk factors for causing mass outbreaks. Authors in each country were asked to list qualitatively key factors causing COVID-19 infection clusters in workplaces or among jobs in terms of basic preventive ways of mitigating the risk of virus infection such as engineering control including ventilation, the provision of personal protective equipment (PPE)

Focus groups constitute a research or evaluation method applied by OH experts for the purpose of collecting qualitative or quantitative data related to virus clusters occurring in workplaces through interactive and directed discussions not only within a country, but also among countries<sup>9</sup>). Authors in each country were asked to list key qualitative factors causing COVID-19 infection clusters in workplaces or among jobs in terms of basic preventive means of mitigating the risk of virus infection, such as engineering control including ventilation and the provision of PPE. We attempted to ensure that the qualitative assessment methods and results were as reliable and scientific as possible by requiring the co-authors to reach consensus through discussion within each country and to engage in consultations with an ANOH member industrial hygiene society.

## Results and Discussion

### *Proportion of workers in the population*

The percentage of workers accounted for in the overall population ranged from 39.1 to 56.6% (Table 2). The definition of a worker varies among countries, but generally

excludes the self-employed. Most of the workers who have short-term or one-off employment contracts mediated by platform businesses, or the "gig economy", are often excluded from the labor protections offered to conventional employees. According to Heymann *et al.* (2020)'s analysis of the database of legislative guarantees for paid leave for personal illness in 193 UN member states during the COVID-19 pandemic, 58% of them lacked provisions to ensure that self-employed and gig economy workers have access to paid sick leave benefits<sup>10</sup>.

### *Major occupations with cluster outbreaks of COVID-19 by country*

We found that types of occupations or job groups occurring in workplaces were both different and similar among countries (Table 3). This result is only a qualitative ranking of occupations, jobs, and workplaces with clusters without the exact numbers and can only be compared within a given country because of the lack of national COVID-19 statistics classified by occupational factors. We discuss here the types of occupations or workplaces with the most frequently reported mass outbreaks of COVID-19 in each country.<sup>11,12</sup>

### *Health and social care workers (HSCW)*

Most of the countries studied reported experiencing COVID-19 clusters among HSCW, which may be similar worldwide. It has been well-known that HSCWs are among the groups most vulnerable to infectious disease, including COVID-19. Since COVID-19 first emerged in China in December 2019, most studies have continued to report cluster outbreaks in hospitals and various types of social-welfare-related facilities—including senior care facilities, psychiatric hospitals, long-term care facilities, and nursing homes<sup>13–15</sup>).

**Table 3. The five most frequently reported occupations or jobs with mass outbreaks# of COVID-19 by country as of July 31, 2021**

Country	The five most frequent occupations/workplaces with mass outbreaks <sup>a</sup>	Major risk factors for causing mass outbreaks <sup>b</sup>
India	Wholesale market	Lack of awareness
	Religious sites	Overcrowding
	Slums	Lack of use of PPE
	Wholesale market vendors	Poor hygiene practice
	Military school	Non-compliance with regulations
Indonesia	Health care workers	Information not available
		Exposure to infected patients
		Overcrowding
		Group cycling activities
	Cigarette factory	Exposure to infected workers
Indonesia	Electronics factory	Lack of PPE
		Exposure to infected workers
		Lack of ventilation
	Offices (government offices, offices in high-rise buildings, etc.)	Overcrowding, insufficient ventilation
		Poor indoor air quality
Japan <sup>c</sup>	Garment	Exposure to infected workers
		Poor indoor air quality
	Health care workers (licensed 5,749)	Exposure to infected patients/poor infection control
	Social insurance, social welfare, and care services such as childcare professionals (unlicensed) (321)	Poor infection control
	Health care industry (unlicensed) (238)	Exposure to infected patients/poor infection control
Malaysia	Transport and postal activities such as bus, taxi, or truck drivers (216)	Poor infection control
	Industries unable to be classified (147)	Poor infection control
	A factory with migrant workers making gloves	Migrant workers living in dense shared quarters
	Vehicle workshops	Overcrowding of work premises – inadequate physical distancing
	Construction	Non-compliance with government SOP
New Zealand <sup>(1)</sup>	Public institutions, including hospitals (health care workers)	Poor ventilation
	Supermarkets	Close proximity
	NZ does not break down cases by occupation, but by clusters	Mainly overseas links and social gatherings outside of work
Republic of Korea <sup>(2)</sup>	Health care workers	Exposure to infected patients/lack of PPE/poor infection control
	Workplaces with migrant workers	-
	Call center	Lack of PPE/lack of ventilation/dense working area/poor infection control

Table 3. Continued

Country	The five most frequent occupations/workplaces with mass outbreaks <sup>a</sup>	Major risk factors for causing mass outbreaks <sup>b</sup>
	Retailer: logistics	Share PPE/lack of ventilation/dense working area/poor infection control
	Detention center	Lack of PPE/lack of ventilation/dense facility/poor infection control
	Food and dining facility/religious facility/army.	Lack of ventilation/frequent contact/poor infection control
	Others	-
	Health care workers and police/military personnel	Client interaction
Republic of Philippines	Public/company transport facilities, manufacturing/production areas, canteens while eating, lounges/rest areas	Areas where workers converge
	Designated smoking areas	Non-use of PPE
	Workplaces with migrant workers	Exposure from original countries/poor infection control of workers
	Health care workers	Exposure to infected patients/lack of PPE/poor infection control
	Pilots	Exposure from flied countries/dense working area/poor infection control
Taiwan	Entertainment sites	Dense facility/Poor infection control
	Quarantine hotel workers	Exposure to infected patients/dense working area/poor infection control
	Construction worker camps	Unaware of COVID-19, No PPE
	Cold storage factory	Migrant workers in the community. Crowded places, which are high-risk areas, Lack of PPE
Thailand	Shoe factory	Poor infection control, Lack of PPE
	Workplaces with migrant workers	Migrant workers in the community. Crowded places, which are high-risk areas, Lack of PPE
	Entertainment site	Poor infection control, Lack of PPE

Abbreviation : PPE, personal protective equipment.

<sup>a</sup>The ranking of clusters was qualitatively determined by the authors based on either news media or official reports by the health authority.

<sup>b</sup>Listed qualitatively by the authors in each country and summarized by country.

<sup>c</sup>Released by the Japanese government as of July 31, 2021.

COVID-19 statistics worldwide demonstrate a particular severity among individuals residing in long-term care facilities. More than 40 percent of all reported COVID-19 deaths in the U.S. have occurred in nursing homes<sup>16</sup>. The spread of infection may have originated from staff, possibly before they displayed apparent symptoms, and contributed to the extensive spread of COVID-19 in nursing homes<sup>17</sup>. There is a possibility that they could be a source of COVID-19 infections and mass infections as they continue to commute, while patients hospitalized in welfare-related hospitals pose relatively lower risks of virus transmission since they were tested prior to admission.

A shortage of PPE, long exposure to large numbers of infected patients, inadequate training on infection prevention and control, and exposure to unrecognized COVID-19 patients have been the most prominent determining causes<sup>18, 19</sup>. Any recognition that the hospital is not only a service space for patients to be cared for and treated, but also a workplace where HSCW should be able to work safely and without risks to their health, is rare<sup>20</sup>.

#### *Detention, correctional facilities, and prisons*

Mass clusters of COVID-19 in prisons were reported in the Republic of Korea. The highest number of new daily COVID-19 cases came in late December 2020 at a corrections and detention center in South Korea. Virus transmissions tied to the detention center marked the single-largest outbreak incident, triggering concerns that the prison could become a new cluster of infections<sup>12</sup>. This result is in agreement with COVID-19 outbreaks in prisons and jails reported in China, the U.S., and elsewhere<sup>21–23</sup>. One study using U.S. state and federal prison data found COVID-19 infection rates five times higher in prisoners than in the general public<sup>23</sup>. Inadequate ventilation systems, limited PPE availability, overcrowding, poor health services, and a large proportion of individuals susceptible to COVID-19 are vital factors that have led to the spread of infection. In addition, their architectural and structural characteristics make prisons potential epicenters for infectious disease. Throughout the world, prisons have been regarded as a perfect environment for the spread of infection<sup>24, 25</sup>.

#### *Migrant workers*

Three countries reported mass clusters of COVID-19 among migrant workers; the Republic of Korea, Taiwan, Malaysia and Thailand<sup>26</sup>. Our results are in agreement with existing studies reporting that poor living and working conditions, including cramped workers' dormitories and unsanitary conditions, led to the rapid transmission of infec-

tion of COVID-19 among migrant workers<sup>27</sup>. The United Nations High Commissioner for Refugees (UNHCR) reports millions of refugees and migrants in camps and detention centers worldwide<sup>28</sup>. A significant number of these migrants are low- or semi-skilled workers who live in conditions that feature social overcrowding and inadequate hygiene<sup>29</sup>. On top of that, they have few labor rights, which impacts their capacity to reject poor or dangerous working conditions. Similarly, they are less likely to complain about poor working conditions and actualize their occupational health and safety rights and entitlements<sup>30</sup>. Their living conditions and overcrowding in dormitories could provide an environment vulnerable to infection, such as through the mingling of residents in common areas and shared facilities, including toilets and recreational, cooking, and dining areas. In addition, many essential workers employed in precarious jobs with low pay and poor job security are immigrants or migrant workers, which can increase their susceptibility to social and health inequities<sup>29, 31</sup>.

#### *Call centers*

Mass outbreaks at call centers among the participating countries were reported only in the Republic of Korea. Consistent cluster outbreaks have appeared at call centers throughout the country from the beginning of the pandemic, resulting in an attack rate of 43.5% (95% CI 36.9–50.4%)<sup>32</sup>. Most of these employees had worked without face masks being continuously engaged in phone calls through headsets within an enclosed space. Call centers are known for their poor working conditions, a lack of influence by employees, high job demands, often being crowded, lacking ventilation, having workers close by, and generating contaminated body fluids through the response to calls. These outbreaks demonstrate how a high-density work environment can become a potential source and site for intensive transmission and spread of COVID-19 infection. Most large companies and governmental bodies maintain own their call centers, and they vary widely in terms of the work environment and employment status provided to workers.

#### *Retail and grocery*

Workers employed at the largest logistics center for online retailers in several countries have contracted COVID-19 (Table 3). Retail establishments have been reported to be linked to COVID-19 outbreaks among both employees and customers, indicating that the infection risk is higher in relatively crowded stores visited by lower-income customers<sup>33</sup>. Large logistics centers and warehouses are generally

used as spaces where products and parcels are sorted, loaded, and delivered nationwide. Logistics maintains both room-temperature warehouses and low-temperature storage facilities, which can be conducive environments for viral contamination. PPE such as helmets, goggles, gloves, and shoes was reportedly shared by multiple employees in Korea, facilitating the spread of COVID-19. Moreover, multiple firms shared a logistics center. Grocery store employees have also been at high risk for developing infections. Lan *et al.* (2020) found that 20% of grocery store workers in the U.S. tested positive for COVID-19<sup>34</sup>. Factors that increase their risk include encountering a high volume of customers (who may or may not have been wearing masks, especially in the early days of the pandemic) and the inability to social distance.

#### *Garment*

COVID-19 cluster outbreaks occurred among ready-made garment (RMG) workers in both India and Indonesia. An overcrowded working environment in a small space was a significant factor. COVID-19 infection may be closely with the nature of the RMG workplace, characterized by unhygienic and unsafe working environments, hazardous conditions in factories, and a lack of safety equipment, has led to health vulnerabilities among RMG workers in South and Southeast Asia<sup>35</sup>. In Indonesia, even though there was no official statement from the government about an outbreak in the garment industry, local online news claimed that inconsistency in health protocol implementation, including the wearing of face masks, has caused COVID-19 transmission in the garment industry in Klaten<sup>36</sup>. Garment factory workers, along with wholesale market vendors, large-scale construction workers, migrant laborers, and HSCW, are among the occupations reported to have a major cluster of infections in India. These outbreaks have been sporadically highlighted in the mass media but confirmed official reports are largely lacking.

#### *Other jobs or workplaces with COVID-19 clusters*

COVID-19 clusters among other occupations and essential workers, including military personnel, teachers, religious workers, transportation workers, factory workers, and quarantine hotel workers, have been reported in public facilities or either one or two countries studied (Table 3). This study summarizes that COVID-19 clusters are likely to occur in workplaces and occupations where workers remain in enclosed, crowded settings and at factories that accommodate company dormitories. Some of the outbreaks that occurred among workplaces and jobs may be due to an

outbreak in other communities outside the workplace. The number of confirmed virus cases and type of occupations or workplaces with clusters may vary greatly between countries due to differences in the level of national prevention measures and actions taken against COVID-19, the quality of the public health system, and features of industries and jobs.

The COVID-19 pandemic is changing the paradigm regarding high-risk occupations. Several types of jobs or professions in the manufacturing, services, and construction industry that have not been traditionally regarded as at a high risk for industrial accidents have been vulnerable to infections like COVID-19. No country maintains nation-level statistics regarding infection biohazard-caused diseases classified by occupational factors, making it impossible to compare high infection risk occupations among countries<sup>6</sup>.

The main limitation in listing the major jobs or workplaces with relatively the most COVID-19 patients within each country is that they cannot be directly compared among countries due to the lack of international COVID-19 statistics classified by occupational factors, unlike in the case of internationally standardized industrial accident statistics. The type of jobs or workplaces with virus clusters and major factors causing infection clusters can differ depending on the circumstances and response capacity of the country or workplace and the pandemic period.

In addition, the references used to evaluate and list the type of jobs or workplaces and major factors causing COVID-19 clusters were not fully cited due to difficulties such as language barriers and lack of acceptance as journal references. International collaborate studies often might have these inherent limitations. Nonetheless, this study provides the opportunity to describe significant occupations and workplaces with the most frequent COVID-19 virus clusters by country, albeit informally.

#### *Conclusions*

Types of jobs and workplaces where cluster outbreaks frequently occurred were different among countries, except for certain common professions or groups such as HSCW and immigrants. There are high-risk occupational factors for COVID-19 regardless of the type of occupation or workplace: dense work environments with a lack of ventilation, residing in dormitories without proper distancing rules, inadequate infection control measures, and shortage of essential PPE supplies. Types of jobs or workplaces with clusters may vary greatly between countries due to differences in the level of national prevention measures and ac-

tions taken against COVID-19, the quality of the public health system, and features of industries and jobs. This study recommends that COVID-19 infection statistics should be classified by standardized occupational variables to allow them to be compared among countries. Further study is necessary in order to seek ways to control infection risks, including revisions to industrial-health-related laws.

### Conflict of Interest

All authors have no conflicts of interest to declare.

### Author Contributions

A.S. and K.J. conceived the ideas; K.J. and R.L.M. collected the data; R.L.M. and P.A.K. analyzed the data; and A.S. and K.J. led the writing;

M.T., W.P., J.K., J.P. and D.P. drafted the work or revised it critically for important intellectual content; F-J.T., G.M., D.M., A.R., N.G., C.C., M.B.Z.F., Y.L., R.C., K.H.L., J.P., H.H., H.K., C.Y., C.P., E.S. contributed to data acquisition, analysis and interpretation of results; D.P. led all process of the work.

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